# CASE STUDY

## Case New Holland
## Basildon, UK
## Evaluating Tractor Sound Quality

<div align="right">
Europe

Automotive

NVH Simulator
</div>

*Case New Holland (CNH) is a world leading manufacturer of mechanised agricultural equipment. It is listed on the New York Stock Exchange, and its majority shareholder is the Fiat group. CNH was formed in 1999 by the merger of New Holland NV and Case Corporation. The CNH "gene pool" includes a family of modern and historic brands such as Braud, Case, Claeys, Fiat, Flexicoil, Ford, International Harvester, New Holland, Steyr, and many others. CNH spans the globe with representation in approximately 160 countries and a workforce of over 25000. CNH is organised by global brands – Case IH and New Holland in agricultural equipment, and Case and New Holland Construction in construction equipment.*

*Photographs by kind permission of Case New Holland*

## Brüel & Kjær

Basildon, UK is the world headquarters of the New Holland brand. The production and R&D facility based at this location is dedicated to the New Holland brand and specialises in the development and manufacture of mid-sized tractors. A loyal Brüel & Kjær customer, CNH uses PULSE™ for a variety of general tests from sound power to sound and vibration troubleshooting with options such as Order Tracking, Sound Intensity, and Modal. When questioned about the benefits of PULSE, Steve Lyddon, the European NVH manager explained, "It's easy to use, and allows you to get your results on-screen quickly".

To maintain competitiveness in a market where emissions legislation and increasing customer demands drive an aggressive product development, the NVH group within CNH continually investigates their competitive situation regarding ride comfort, vehicle noise, and sound quality in particular. Customer feedback was showing that continual reductions in overall sound pressure levels (down to 69.5 dBA) was accompanied by increased customer satisfaction. However, sound pressure level reductions have made customers more aware of the characteristics of the sound and its quality or refinement.

### Benchmarking Cabin Sound Quality

*From left to right: Steve Lyddon, Fraser Henderson, and Philippe Herrou*

Despite having their own sound quality capabilities, NVH Manager Steve Lyddon and Development engineer Philippe Herrou decided to work with external consultants specialising in sound quality techniques and processes. CNH selected Sound and Vibration Technology (SVT) a collaborative partner of Brüel & Kjær, as the company to work with. SVT's extensive NVH and especially sound quality expertise comes from decades of collective experience in the automotive industry working on car programs for many OEMs. Additionally, SVT could offer something more, something unique – the Brüel & Kjær NVH Simulator which accurately recreates the noise and vibration of a vehicle in a user interactive environment.



The starting point of the process was to benchmark the cabin sound quality against the best in class (BIC) competitor tractor. Now for some, the sound quality process might involve doing a listening test (Jury evaluation) on the sound played back over headphones to determine customer preferences and creating a combined sound quality metric to describe it.

For SVT a more holistic, engineering-based approach is taken. This involves decomposing the sound into its principal harmonic and masking components, using engineering information to determine the contributing mechanical components and building up a model based on measured inputs (forcing functions) and transfer paths for the contributing components. This combined Sound Quality/Source Path Receiver (SPR) type modelling, gives an in-depth understanding of the noise generation and transfer mechanisms, simplifying the process of engineering a solution as you know where to look and can play "what if" scenarios with the data by manipulating paths and excitation levels.

For Fraser Henderson of SVT, this job presented some new challenges, required data resolution and important parameters. For although modelling passenger cars was well known to SVT, tractors were a different matter. After investigation, it became clear that it was necessary to measure as high as the 300th order to build a realistic model. The modelled vehicle sound was then compared to the original sound as a check – did it still sound the same as the original recording. The data was loaded into the NVH simulator (for more details see box text). Three actual tractors were tested and had simulator models built, and these models were modified to produce an additional four virtual tractors on the simulator.

A jury was put together with members from the marketing, after sales, and development departments. The task was to evaluate the seven tractors in terms of their cabin sound quality. Compared to a traditional sound quality jury test, working with the simulator adds interactivity and context that make the whole experience less abstract and more realistic, leading to clearer preferences from the jury.

**Better than BIC**

The jury test using the simulator provided a transparent process whereby all of the participants were able to relate what they were judging to a real life test object. The participants were unable to distinguish between the real vehicles and the virtual vehicles created. The expectation was to be able to simulate changes to the CNH tractor that identify noticeable improvements to sound quality levels. The result was the development of a model that exceeded the sound quality performance of the BIC tractor in the opinion of the jury.

Another interesting by-product was the better understanding of the customer perception and weighting of the cabin noise, which led to certain sound components being left in to enhance the "brand" sound. This process enables targets to be set for individual components, and transfer path characteristics to be defined in order to achieve the target sound. In other words, accurate subjective preferences can be converted to clear engineering targets, the dream of all sound quality engineers. CNH were so pleased with the result that they plan to continue this process for future models. So, should you be passing a field somewhere and hear a sexy sounding tractor, you should be able to guess the brand.

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**Today's Tractor**

Those with no involvement in construction or agriculture may be forgiven for not knowing how far the modern tractor has evolved from the simple device with the open cab that many of us still imagine to be a tractor. In the case of the medium size agricultural tractor such as the T7000 series covered in this case study we are talking about a vehicle that costs over $100 000 with 175 kW engine performance with Power Boost at its disposal.

Tractors are required to be able to operate over a speed range of 0.25 km/h for field work up to 50 km/h when transiting by road. Combining these requirements with the engine load variations such as when ploughing or powering equipment from the Power Take Off (PTO) coupling, have led to sophisticated gearboxes that nowadays are electronically controlled and operated by push button with 18 – 24 gear ratios or even a Continuously Variable Transmission (CVT).

**Comfort**

The tractor may be driven over rutted fields for many hours a day, punishing the driver with continual jolting. To combat this, various systems are employed including pneumatic seat suspension, cab suspension, front axle suspension, and dynamic control of implements. Both noise and vibration fatigue also affect the operator's comfort in the cabin. Despite the presence of complex noise and vibration sources such as the complicated gearbox, hydraulic systems, many ancillaries combined with typical diesel engine noise, SPL levels inside a modern tractor are between 70 and 76 dBA. In fact, the T7000 boasts the quietest cab in the industry at 69 dBA – less than you may have in a family saloon car.

Looking at the cockpit you can see how far tractors have come in the last few years and it is now common to have somewhere to place your laptop, which can be used together with GPS to ensure efficient working. With this in mind, it is no surprise that today's tractor market resembles the car market with emphasis not only on performance and reliability but also on "soft" values like refinement, aesthetics and even gadgets.

## What is the NVH Simulator?



The NVH simulator is a tool that enables users to interact with and evaluate measured or simulated NVH measurement data. It is based on an NVH data model of the test object that includes a matrix of sound and vibration data measured under a number of operating regimes. To build the model, measured data is decomposed into engine orders and masking sounds such as wind and road noise, before being reconstituted into an interactive parametric model of the test object's NVH performance. Where measured data is not available, synthesised or numerically modelled data can be used. The simulator model can then be "driven" using the compact desktop simulator which provides a driving environment with all major controls on a desktop including steering wheel and pedals.

To add realism there are interactive visuals which provide a driving environment so that the operator carries out the evaluation under conditions that mimic real life rather than the typical sound quality approach that has the juror sitting in an artificial environment such as a listening room.

The fact that the system provides a simulated driving experience lends context and interactivity which are essential for producing realistic assessments from the jurors. Because the model is parametric, it becomes much easier to play out realistic modifications to the test object by retuning the balance of the orders, changing body transfer functions or changing the nature and level of the masking. The ability to use numerical data from simulations as part of the input for the model, in effect allows you to evaluate components and modules prior to building them.

The NVH simulator represents one of the most significant advances in NVH engineering development of the last decade as it provides a new way of working with NVH data. It allows realistic, and repeatable assessment of NVH data by real people (not just engineers) and provides a direct link between the perceived sound and vibration and the source mechanisms creating them, removing much of the guess work from engineering.

The NVH simulator is available as a desktop unit or as a full vehicle simulator where it is built into a car of the customer's choice and vibration stimulus is added to allow secondary ride characteristics to be evaluated.

Brüel & Kjær supplies a family of data preparation tools and complementary products such as our SPC (Source Path Contribution) solution to help you work with the simulator.

*For additional information about the PULSE NVH Vehicle Simulator, please see* Product Data: PULSE NVH Vehicle Simulator

*The Simulator can be provided as a turnkey solution or made available on a consultancy basis.*

**Brüel & Kjær**